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Automated Milk Quality Analyzer with Billing System

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Abstract**—** *Agriculture is an important part of India's economy, and the dairy sector provides to the country's profitability. As we all know, the global has grown at a faster rate, with people embracing a more affluent lifestyle to meet shifting expectations and needs. As a result, it is critical to reform the current farming and dairy management practices in India in different criteria, such as FAT, classifications of various milk characteristics, and so on. Another concern is that the process is done manually, which makes it susceptible to errors. As a result, it is necessary to reduce physical labour to improve results. The current system must be replaced with a new one that utilizes automated milk sample measuring technology. In our proposed system, we have developed a low-cost and reliable milk parameter detection and analysis system that uses an Arduino controller. On the other hand, the milk quality is checked, evaluated, and shown in a matter of seconds. As a result, the goal of implementing the suitable information technology stated in this project is to make information symmetric in the market, thereby minimizing problems of adverse selection and tedious work.*

Keywords**— *Milk Analyzer, Fat, Ammonia, Humidity, Billing System.***

I. INTRODUCTION

In India, milk production yields a larger return for both farmers and dairy farms. Milk and milk items are consumed by almost Eleven billion people across the world, with 70 per cent of children suffering from malnutrition each year. Adulteration is one of the major problems in India and also in some of the developing countries and in some advanced countries too. Many milk producers and sellers add adulterants such as urea and common salts are added to increase solid-not-fat (SNF), Ammonium sulphate is added to increase the lactometer reading by maintaining the density of diluted milk, Formalin, Salicylic acid act as preservatives and increase the shelf life of the milk.

Many scientific papers have been proposed on the detection of milk adulteration and adulterants present, the paper by Vasudha V Ayyannawar Et al. [1] proposes a system that allows you to justify the quality of milk. On the LCD, the exact FAT values are displayed, and these values are instantly communicated over the internet, where anyone can obtain the information. Farmers will be able to sell their milk at a reasonable price as a result of these accurate valuations. The writers Dr G Rajakumar Et al. [2] designed an IoT-based system in this research that provides faster and more reliable results. Microbial activity is measured using a gas sensor in our suggested method, a level sensor is used to identify the level of the milk, as high-quality milk should have no salinity. This technology measures milk collection factors such as weight, FAT, and CLR and provides quick results. The work by S Priya Et al. [3] is based on smart sensor technology, this project determines the parameters of milk. Here, we consider parameters like temperature and pH to determine the quality of the milk. The Temperature sensor is used to determine the hotness or coldness of milk. The pH sensor is used to determine the pH of the milk.

In this paper, we have proposed a system for the creation and deployment of a low-cost and reliable milk parameter detection and analysis system utilising an Arduino controller. The prototype is a basic milk analysing system using a phototransistor and a coupled LED as a module. The transmitter and receiver are separated by a modest distance inside the container sample setup. As a consequence, the findings are examined based on the

change in resistance produced by the fat content in milk. The gas sensor is used to detect microbial activity in milk, while the humidity sensor provides humidity information. Finally, the processed data is presented on an LCD panel and updated on the ThingSpeak cloud platform, which allows data to be accessed over the internet. A billing system is established, in which each user will have their own data set with data collected for the amount of milk generated.

The paper has four more chapters. Chapter 2 gives the details of the motivation behind the selection of the project. Chapter 3 includes the block diagram of the complete prototype, an Input section consisting of a setup of LED coupled with LDR, gas & humidity sensors, an Output section consisting of an LCD & ThingSpeak database and the Circuit diagram of the prototype. In chapter 4, the experimental results of the prototype with different types of milk analysed are shown in a tubular column and their respective outputs are displayed in LCD and uploaded to ThingSpeak. Chapter 5 provides the conclusion and future enhancement.

II. MOTIVATION

i. There are many new technologies included in the determination of adulterants in milk, but these technologies are still not affordable for small industries and farmers to evaluate milk quality and determine an exact price for milk based on that quality.

ii. Milk processing takes longer since it must first be evaluated for quality by measuring its FAT content, density, and quantity after being purchased from farmers. As this process is time-consuming hence farmers have to stay in line for an hour or more.

iii. The milk sample for testing is kept in plastic bottles and only assessed once the milk collection process is over, thus the sample will be checked after one or two hours. Some milk collection sites do not have the most up-to-date milk analysing equipment.

iv. Since all measurements are performed manually, there is a potential that cooperative staff members' handwritten calculations of quality and quantity contain inaccuracies.

III. PROTOTYPE DEVELOPMENT

To run a Milk Analyzer in real-time accurate hardware components and software components in addition to network connectivity. The milk analyser uses multiple sensors to test various parameters. These sensors include gas, humidity and temperature sensor & a module coupled with LED & LDR. These sensors provide various readings that will help analyse for better detection of milk parameters.

The sensors are connected to the microcontroller which is used for data acquisition and signal conditioning. The data acquired by the sensor is converted into a form more suitable for computation for the microcontroller. On these values, the generation of the bill is done. These values are temporarily stored in Arduino & connect to the ThingSpeak database via a Wi-Fi module on which measured values and bill amount is sent. The following block diagram depicts the proposed prototype of the milk analyser along with database storage.

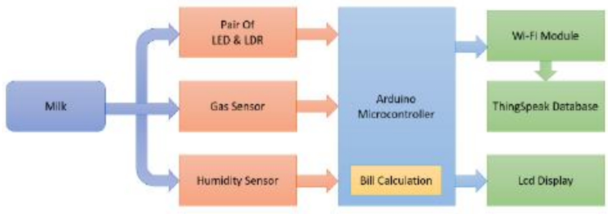

Fig. 1. Block diagram of our proposed prototype

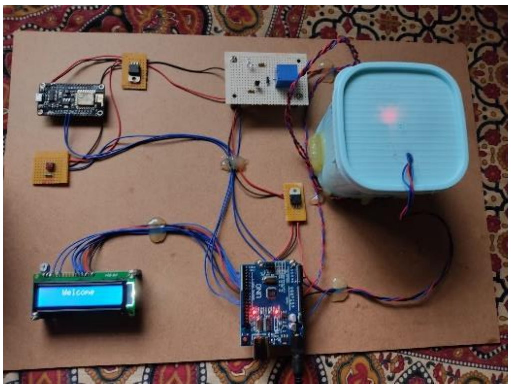

Fig. 2: Proposed Prototype

3.1. INPUT SECTION

The input segment consists of three inputs namely a setup of LED & LDR, a Gas sensor and a Humidity & temperature sensor. This sensor measures the three parameters of our prototype namely, FAT % in the milk, chemical additives added to milk & moisture content of the milk sample.

3.1.1. Setup of LED & LDR

The Fat% is obtained on basis of the light scattered in the milk. The photoresistor, whose resistance varies as the number of incident light varies. Having a high resistance, it is a semiconductor material. Photoconductivity is the

underlying mechanism at play. As more electrons are liberated as the light fades, more charge carriers, such as holes, are produced. The change in resistance brought on by the milk's fat content allows for an analysis of the results.

To receive fat % in a couple of LED & LDR, an external circuit is required to operate the LED for a certain duration the time. The external circuit consists of a relay, transistor & flyback diode. Below is the External circuit that is required for the operation of the led.

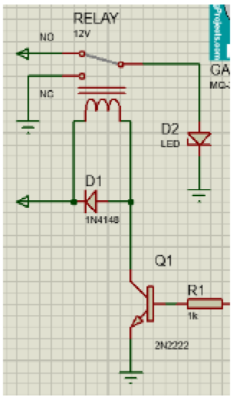

Fig. 3: External Circuit for switching ON/OFF the LED

Once the start button is initiated, the Arduino sends a signal to start the process. The signal to the relay passes the transistor. The relay coil used here is T73 12V DC. The relay coil is switched by an NPN transistor. The transistor is in an open state and thus acts as an open switch and the base voltage is zero. Relay coils are a current device, when no collector current flows through it then there is no current flow through the Base, in this case, the relay coil is de-energized. The current flow between the Base and Emitter i.e., B to E, controls the current flow to the transistor between the Collector to Emitter of the relay coil. The relay coil serves as both an inductor and an electromagnet. A maximum current will flow when electricity is given to the coil as a result of the transistor switching action since the coil has the largest DC resistance, according to Ohm's Law (I = V/R).

A part of this electrical energy is stored in the magnetic field of the relay coil. When the transistor is turned "OFF," the magnetic field decreases thus decreasing the current flow through the relay coil. However, it tries to maintain the current flowing through the relay coil, a reverse voltage arises across the coil because the magnetic field's stored energy must go someplace. This results in a considerable voltage spike across the relay coil that, if allowed to build up, can harm the switching NPN transistor.

Thus, a flywheel diode often referred to as a freewheeling diode, is connected across the relay to guard the semiconductor transistor against damage. To dissipate the stored energy and safeguard the switching transistor, this flywheel diode clamps the reverse voltage across the coil to just under 0.7V. The Arduino is programmed to power the LED for a short duration (2sec) using the external relay circuit. This duration is sufficient for the light to scatter across the container & reach the LDR.

The high beam light from LED is passed through the container that has the milk sample. The high beam light is scattered through the milk & the change in the light beam is received by the LDR. This entire process is taken place inside a Tightly sealed container which has no interaction with the external light. The change in photoconductivity indicates the presence of Fat% content in the milk sample. The incidence of light increases on the LDR, the resistance decreases indicating the Fat% in the milk is lesser and as the resistance increases the amount of Fat% present in milk is more. Thus, LDR generates an output voltage in form of an analog signal which is sent to Arduino to analog input pin A0. The pair of LED & LDR are enclosed inside the container using transparent bottle caps.

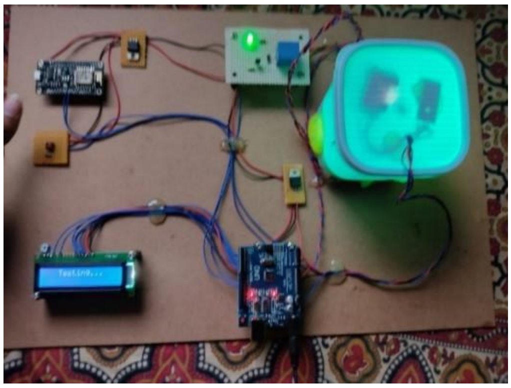

Fig. 4: The testing process of the Milk Analyzer

3.1.2. Gas Sensor

The gas sensor that is used in the prototype is the MQ 2 sensor which detects the presence of Alcohol, Propane, Methane & Carbon Monoxide. When gas contacts the sensing material, its resistance changes, which is the basis for the detection. Gas concentrations are identified by using a voltage divider network.

This sensor has an aluminium oxide foundation with a tin dioxide coating and a ceramic-based detecting component that is encased in a stainless-steel mesh. Six interconnected legs support the sensing element. Two leads do the heat sensing element while the remaining four leads are to provide output signals. The oxygen is adsorbed by the facet of a sensor material when exposed to high

temperature in air. Then, free electrons from tin oxide are influenced by the oxygen, thus arresting the current flow. When the reducing gases are present, the oxygen atoms interact with them and decrease the facet density of the adsorbed oxygen. Analog voltage values were generated because the current is now passing via the sensor. The analogue output voltage of the sensor varies in direct relation to the amount of gas or smoke present. While the output voltage reduces as the gas concentration rises, it increases as gas concentration falls. These voltage readings are taken to determine the gas concentration. When there is a high concentration of gas, voltage levels are greater. These voltage values are fed to the analog input pin A1.

The sensors are used to detect the presence of adulterants present in the container. The insertion of the gas sensor into the milk sample causes damage to the sensor. Hence, it is placed on the lid of the container.

3.1.3. Humidity Sensor

The Humidity sensor used here is DHT11. It is used to detect the freshness of the milk. Using this component, we verify whether the milk is fresh or refrigerated. The DHT11 does the calculation of relative humidity by electrical resistance between two electrodes.

A moisture-holding substrate installed on an electrode surface serves as the humidity sensor for the DHT11. The substrate emits ions as it absorbs water vapour, enhancing the conductivity between the two electrodes. The amount of resistance between the two electrodes varies depending on the relative humidity. The resistance between the electrodes improves with lower relative humidity while it deteriorates with higher relative humidity. The DHT11 converts the resistance measurement which is analog to the relative humidity in digital form which is done by the chip mounted on the back of the unit and transmits the humidity readings directly to the Arduino digital-PWM~ pin 9. Again, the insertion of this module into the milk sample causes damage to the sensor, thus, it is incorporated along with the gas sensor module on the lid of the container.

3.2. MCU (MICROCONTROLLER UNIT)

3.2.1. Hardware

A microcontroller is an integrated circuit with a built-in minicomputer. Microcontrollers are made up of one or more processors, together with peripherals for input, output, and memory. Program memory might be in the form of Read-Only Memory (ROM) or Random Access Memory (RAM). This microcomputer can be utilized in the Internet of Things for data gathering, data actuation, and real-time value sense. For the microcontroller for our prototype, we utilized an Arduino UNO. Based on the ATmega328p microprocessor from Microchip, the Arduino Uno is an open-source microcontroller board made by Arduino.cc. This board for a programmable microcontroller is inexpensive, adaptable, and simple to use.

Signals from the Input section, readings of Fat%, adulterants content and moisture content in the milk are fed to the Pin no A0, A1, and D9 respectively. Using these values, the microcontroller calculates the Bill amount based on the input parameters by programming using the embedded C language. Generation of the bill is done only when the milk sample meets the fixed parameters. Failing to meet one of the parameters, indicating the milk is adulterated. Bill along with the measured parameters is sent to the Wi-Fi module to upload to the database and display them on LCD for the client on spot.

3.2.2. Software

The complete prototype is programmed in embedded C in Arduino IDE. The Arduino IDE is open-source software, which is used to write and upload code to the Arduino boards. It is programmed in such a way that when the MCU receives the three parameters reading, it calculates the bill amount based on the parameters. Failing to meet the parameters generates no result meaning the milk is adulterated. The bill amount along with parameters readings are sent to the Wi-Fi module and display module. The program to connect to a particular network & to transmit, and receive data for the Wi-Fi module is also programmed to the Arduino.

3.3. OUTPUT SECTION

The output segment consists of the ThingSpeak database and the LCD. Bill amount along with parameters is uploaded and displayed respectively.

3.3.1. ThingSpeak Database

ThingSpeak is an open-source software which allows users to communicate with internet-enabled devices. The ThingSpeak Offers an API to both the network websites and the network-enabled devices making data access, retrieval, and logging easier. The output readings from the MCU are stored in the database via a Wi-Fi module. The ThingSpeak stores the data and plots the parameters against the time the test is done. By storing these values, both the vendor & client have the access to the database to monitor the milk flow. Transaction of the amount for the milk can be done weekly or monthly according to convenience.

In this paper, we make use of the NodeMCU ESP8266 Wi-Fi module. NodeMCU is an open-source development board based on the widely used ESP8266 Wi-Fi module. It allows the programmer to program the

ESP8266 Wi-Fi module. The programming language used here is embedded in C. The Wi-Fi module is programmed on how to communicate with MCU on the communication bus and the transfer of data to the ThingSpeak cloud database for data storage. The module is configured to only a particular network to ensure the transfer of data in a secured way. Network username and password are programmed in the MCU. For each individual, a separate channel has to be created that stores the data entries of that particular individual. Multiple channels have to be created to use for multiple clients.

3.3.2. LCD Display

The LCD Unit deployed here is a 16*2 Display. The LCD 16*2 is a type of electronic display that shows information and messages. It has 16 Columns and 2 Rows, as the name would imply, allowing it to show a total of 32 characters (16*2=32).

The Bill amount along with Fat%, adulterant gas & humidity content is displayed for the client. These values are displayed on display at an interval of 5sec. Both the client & vendor get these results on the spot in a matter of sec after the entire process.

3.4. CIRCUIT DIAGRAM

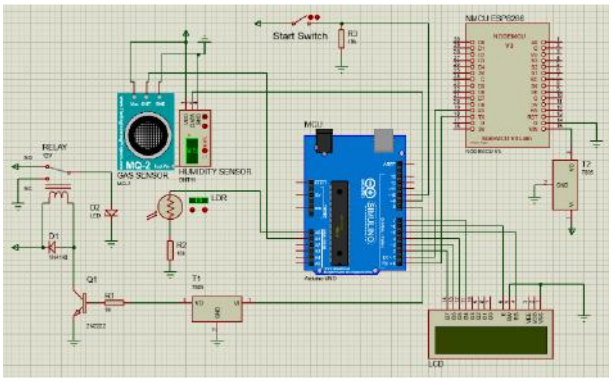

Fig 5: Circuit Diagram of our proposed prototype

IV. EXPERIMENTAL RESULTS

This section briefs about the various tests performed on the variety of cow milk and their corresponding results. To uphold the proper functionality of the system, each component had to be tested individually. To achieve the productive testing of the component, the breadboard and digital multi-meter were used. The testing was performed on each of the components and sections that made up the circuit to ensure the proper and adequate operation of the system.

The milk testing instruments that are available commercially are for the detection of Fat% content in the milk which is expensive. Our prototype produces the same result at a low manufacturing cost. Below are results obtained during the testing of various milk along with adulterants. This chapter is divided into three sections to demonstrate the experimental results of the prototype namely, Validation of Pure Milk, Adulterated Milk & ThingSpeak cloud platform.

4.1. VALIDATION OF PM (PURE MILK)

Below are the pictures obtained during the testing of pure milk.

Fig 6: Fat% of PM

Fig 7: Humidity of PM

Fig 8: Gas Level of PM

Multiple cow kinds of milk were tested and are listed in the below tabular column.

Table I: Validation of PM

Cow No.	Fat% (Measured by the Prototype)	Gas Present (%)	Relative Humidity (%)	Output	Price
C1	9.9	2	71	Normal	31
C2	6.14	2	72	Normal	32
C3	4.63	2	74	Normal	29
C4	4.91	2	73	Normal	29
C5	3.61	1	71	Normal	27
C6	3.06	1	70	Normal	27
C7	4.64	2	74	Normal	29
C8	4.41	2	74	Normal	29

4.2. VALIDATION OF AM (ADULTERATED MILK)

Below are the pictures obtained during the testing of adulterated milk by adding the adulterant to the pure milk.

Fig 9: Fat% of AM

Fig 10: Humidity of AM

Fig 11: Gas Level of AM

Multiple adulterated kinds of milk were tested and are listed in the below tabular column.

Table II: Validation of AM

Cow No.	Fat% (Measured by the Prototype)	Gas Present (%)	Relative Humidity (%)	Output	Price
C1	9.8	9	73	Abnormal	0
C2	6.9	6	79	Abnormal	0
C3	5.37	8	75	Abnormal	0
C4	6.01	9	77	Abnormal	0
C5	5.19	9	75	Abnormal	0
C6	6.35	8	78	Abnormal	0

1.3. THINGSPEAK DATABASE

The entire testing results are updated in the ThingSpeak and are shown below with both the Pure and Adulterated Milk together.

Fig 12: Cloud storage of Fat%

Fig 13: Cloud storage of Humidity

Fig 14: Cloud Storage of Gas

Fig 15: Cloud Storage of Price

V. CONCLUSION

The demonstrated prototype was able to differentiate between adulterated milk and pure milk as shown in Tables I & II. As a result, the designed prototype is compact and portable. It has low power consumption and a fast response time. We can more properly assess milk quality with the aid of this technology, and both clients and vendors will receive regular updates on the milk. Additionally, customers will profit appropriately based on the milk quality, and suppliers will get high-quality milk. Another advantage may be the removal of manual registers used to store all types of information and data.

Our system's measurements of the milk collection characteristics including fat per cent, adulterant, and

humidity produce findings that are comparable to those of older, more sophisticated systems at a lower cost. Simple parts like sensors and NodeMCU are efficiently coupled in the suggested system to help with the administration of diary automation. Thus, the system is portable, easy to use and handle.

Though the Prototype has advantages it also has the limitations such as the determination and Calculation of CLR, and the addition of a pH sensor which enables the further determination of the adulteration. A few of the possible ways to enhance this prototype are mentioned below:

i. Implementing the CLR calculation can enhance further detection of adulterants.

ii. Adding a pH sensor gives the acidity or alkalinity of the milk.

iii. A weight sensor can also be added to calculate the total amount of milk supplied by the client.

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